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# Basic Radio Propagation Predictions

## FOR SEPTEMBER 1951

Three Months in Advance

Issued June 1951

CRPL Series D Number 82

## The Central Radio Propagation Laboratory

The propagation of radio waves over long distances depends on their reflection from the ionosphere, the electrically conducting layers in the earth's upper atmosphere. The characteristics of these layers are continuously changing. For regular and reliable communication, it is therefore necessary to collect and analyze ionospheric data from stations all over the world in order that predictions of usable frequencies between any two places at any hour can be made. During the war, the United States Joint Communications Board set up the Interservice Radio Propagation Laboratory at the National Bureau of Standards to centralize ionospheric work and predictions for the Armed Forces of the United States.

On May 1, 1946, this activity returned to peacetime status as the Central Radio Propagation Laboratory of the National Bureau of Standards. Designed to act as a permanent centralizing agency for propagation predictions and studies, analogous in the field of radio to the reports of the Weather Bureau in the field of meteorology, the Central Radio Propagation Laboratory was established in cooperation with the many Government agencies vitally concerned with communication and radio propagation problems. These agencies are represented on an Executive Council which guides the work of the Laboratory; included are the Department of the Army, Department of the Navy, Department of the Air Force, Civil Aeronautics Administration, Federal Communications Commission, Department of State, Coast Guard, Coast and Geodetic Survey, and the Weather Bureau. In addition, industry is represented by a member of the Institute of Radio Engineers and a member of the Radio Manufacturers Association, while the Carnegie Institution of Washington serves in an advisory capacity and the Research and Development Board has designated an observer.

The Central Radio Propagation Laboratory receives and analyzes data from approximately 60 stations located throughout the world, including 13 domestic and 8 overseas stations which are operated either directly or under contract by the National Bureau of Standards. Ionospheric data and predictions are disseminated to the Armed Forces, commercial users, scientists, and laboratories. The basic ionospheric research of the Laboratory includes theoretical and experimental studies of maximum usable frequencies, ionospheric absorption, long-time variations of radio propagation characteristics, the effects of the sun on radio propagation, and the relation between radio disturbance and geomagnetic variation. In the microwave field, the Laboratory is investigating the relation between radio propagation and weather phenomena, as well as methods by which predictions can be made and radio communications improved in this portion of the radio-frequency spectrum. Another phase of the Laboratory's work is the development and maintenance of standards and methods of measurement of many basic electrical quantities throughout the entire frequency spectrum.

## Basic Radio Propagation Predictions

The CRPL Series D, Basic Radio Propagation Predictions, is issued monthly as an aid in the determination of the best sky-wave frequencies over any path at any time of day for average conditions for the month of prediction, 3 months in advance. Charts of extraordinary-wave critical frequency for the $F2$ layer, of maximum usable frequency for a transmission distance of 4,000 km, and of percentage of time occurrence for transmission by sporadic $E$ in excess of 15 Mc, for a distance of 2,000 km, are included.

Beginning with the September 1947 issue (CRPL-D37) the CRPL-D series, "Basic Radio Propagation Predictions," is available on a purchase basis from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., on the following terms:

| | |
|---|---|
| Single Copy | 10 cents |
| Annual subscription (12 issues) | $1.00 |
| (To foreign countries not extending franking privileges, $1.25) | |

The rules of the Superintendent of Documents require that remittances be made in advance either by coupons sold in sets of 20 for $1 and good until used, or by check or money order payable to the Superintendent of Documents. Currency, if used, is at sender's risk. Postage stamps, foreign money, and defaced or smooth coins are not acceptable. Postage is not required in the United States, to United States possessions, and to countries extending franking privileges. Remittances from foreign countries should be by international money order payable to the Superintendent of Documents or by draft on a United States bank.

Address subscriptions, remittances, and all inquiries relating thereto, to the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

The printing of this publication has been approved by the Director of the Bureau of the Budget, May 23, 1949.

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U. S. DEPARTMENT OF COMMERCE
Charles Sawyer, Secretary
NATIONAL BUREAU OF STANDARDS
E. U. Condon, Director

JUNE 1951
CRPL Series D
Number 82

# BASIC RADIO PROPAGATION PREDICTIONS

For SEPTEMBER 1951 — Three Months in Advance

## Introduction

The CRPL-D series, "Basic Radio Propagation Predictions," issued by the National Bureau of Standards, contains contour charts of $F2$-zero-MUF and $F2$-4000-MUF for each of the three zones, W, I, and E, into which the world is divided for the purpose of taking into consideration the variation of the characteristics of the $F2$ layer with longitude (figs. 1 to 6); the world-wide contour chart of $E$-2000-MUF (fig. 7); the contour chart of median $fEs$ (fig. 8); and the chart showing percentage of time occurrence for $Es$-2000-MUF in excess of 15 Mc (fig. 9).

Methods for using these charts are given in Circular 465 of the National Bureau of Standards, entitled "Instructions for the Use of Basic Radio Propagation Predictions," and available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price 30 cents (foreign, 40 cents). Requests for this manual and for the basic predictions from members of the Army, Navy, or Air Force should be sent to the proper service address as follows. *For the Army:* Office of the Chief Signal Officer, Department of the Army, Washington 25, D. C., Attention: SIGOL–2. *For the Navy:* Chief of Naval Operations, Department of the Navy, National Defense Building, Washington 25, D. C. (CNO OP–201Q). *For the Air Force:* Director of Communications, Department of the Air Force, Washington 25, D. C., Attention: AFOAP.

Following figure 9 of each issue, sets of auxiliary figures (nos. 1, 2, 11, 12, NBS Circular 465) or forms CRPL–AF and AH are given in rotation, two in each issue of CRPL Series D. They are necessary or useful for the preparation of tables and graphs of MUF and FOT (OWF), as explained in NBS Circular 465.*

The charts in this issue were constructed from data through March 1951, together with a predicted smoothed 12-month running-average Zürich sunspot number of 54, centered on September 1951.

Attention is invited to the blank form at the end of this publication, for use in reporting the accuracy of the predictions of MUF and FOT (OWF) as given in this report. Communications should be addressed to Central Radio Propagation Laboratory, National Bureau of Standards, Washington 25, D. C.

Information concerning the theory of radio-wave propagation, measurement technics, structure of the ionosphere, ionospheric variations, prediction methods, absorption, field intensity, radio noise, lowest required radiated power and lowest useful high frequency is given in Circular 462 of the National Bureau of Standards, "Ionospheric Radio Propagation." This circular is available from the Superintendent of Documents, price $1.00 (foreign, $1.25).

**Caution*: Each contour chart in Circular 465 and in the CRPL series D reports, as well as the great circle chart, should be 9 (nine) inches in length. The world map should be 9 (nine) inches between the outer 60°-meridians. Unfortunately this scale was not maintained in a reprinting of Circular 465.

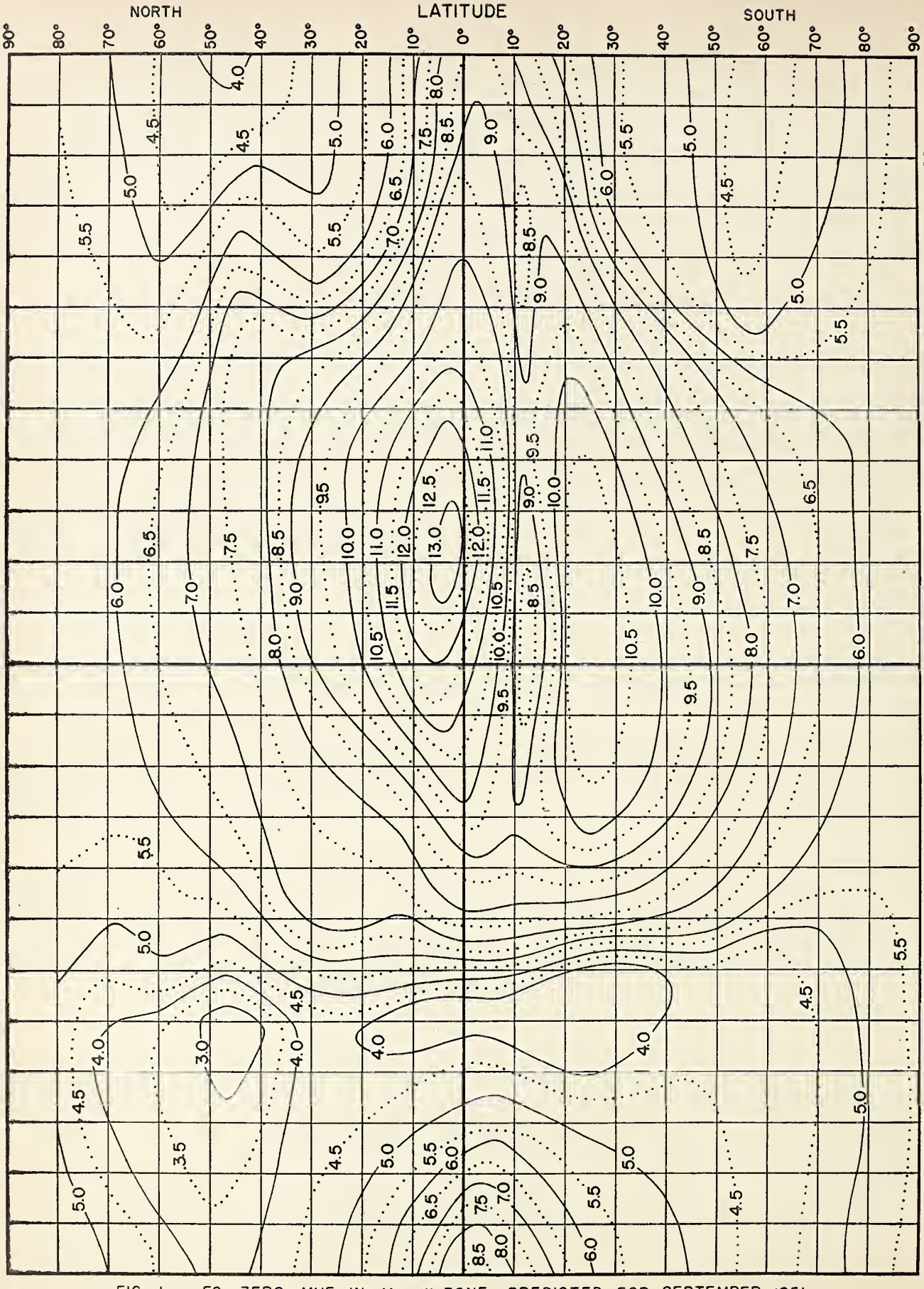


FIG. 1. F2—ZERO—MUF, IN Mc, W ZONE, PREDICTED FOR SEPTEMBER 1951.

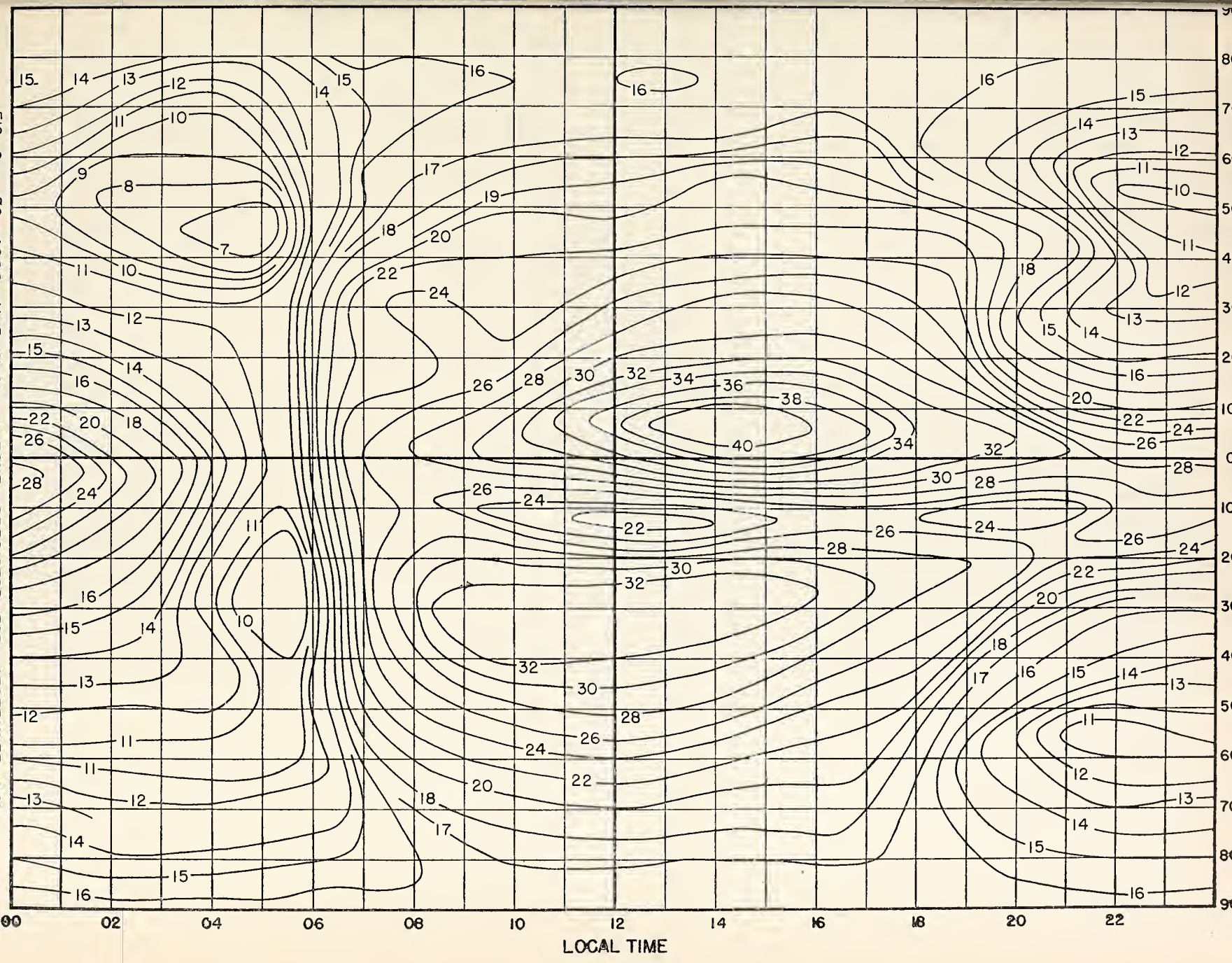


FIG. 2 F2-4000-MUF, IN Mc, W ZONE, PREDICTED FOR SEPTEMBER 1951.

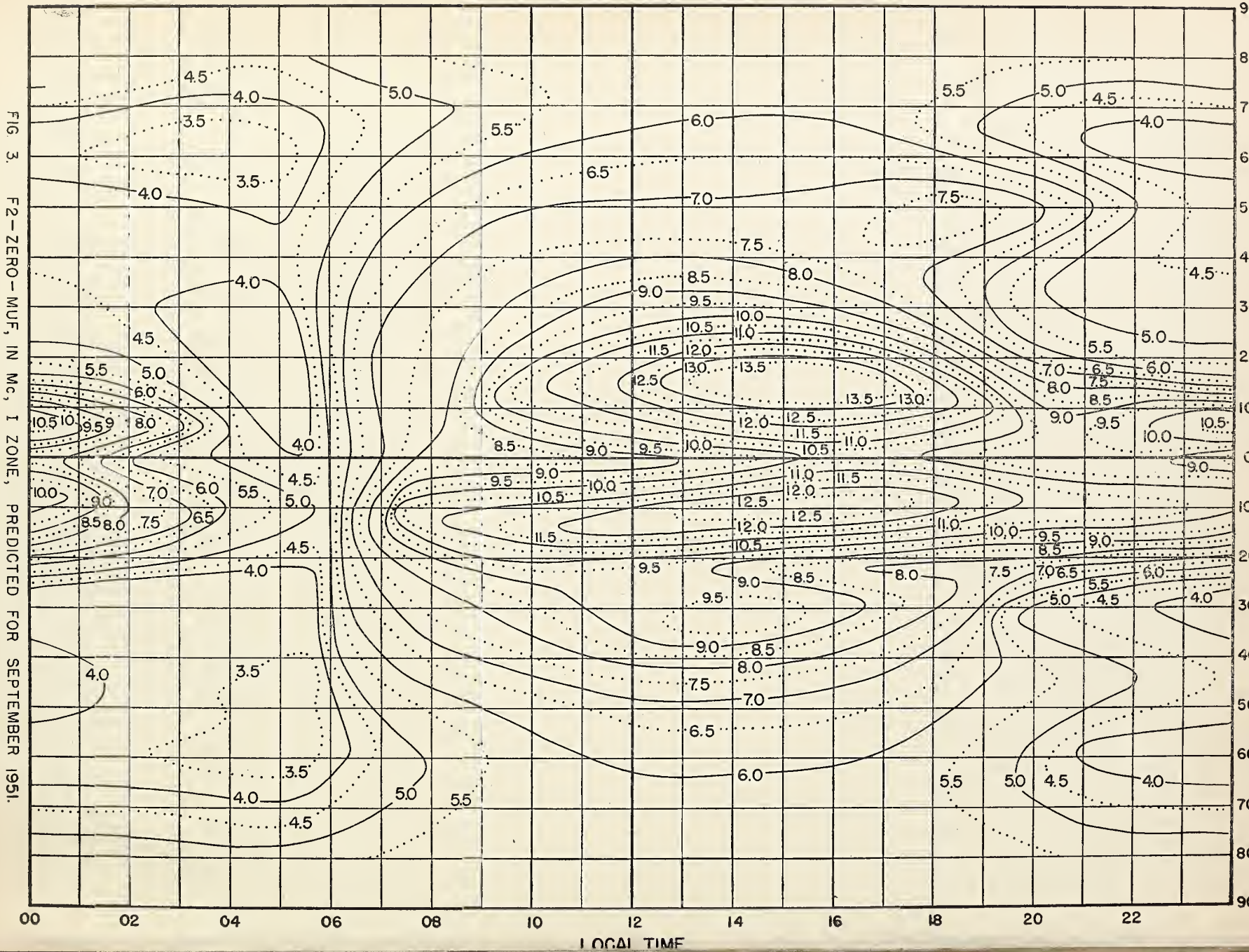


FIG 3. F2-ZERO-MUF, IN Mc, I ZONE, PREDICTED FOR SEPTEMBER 1951.

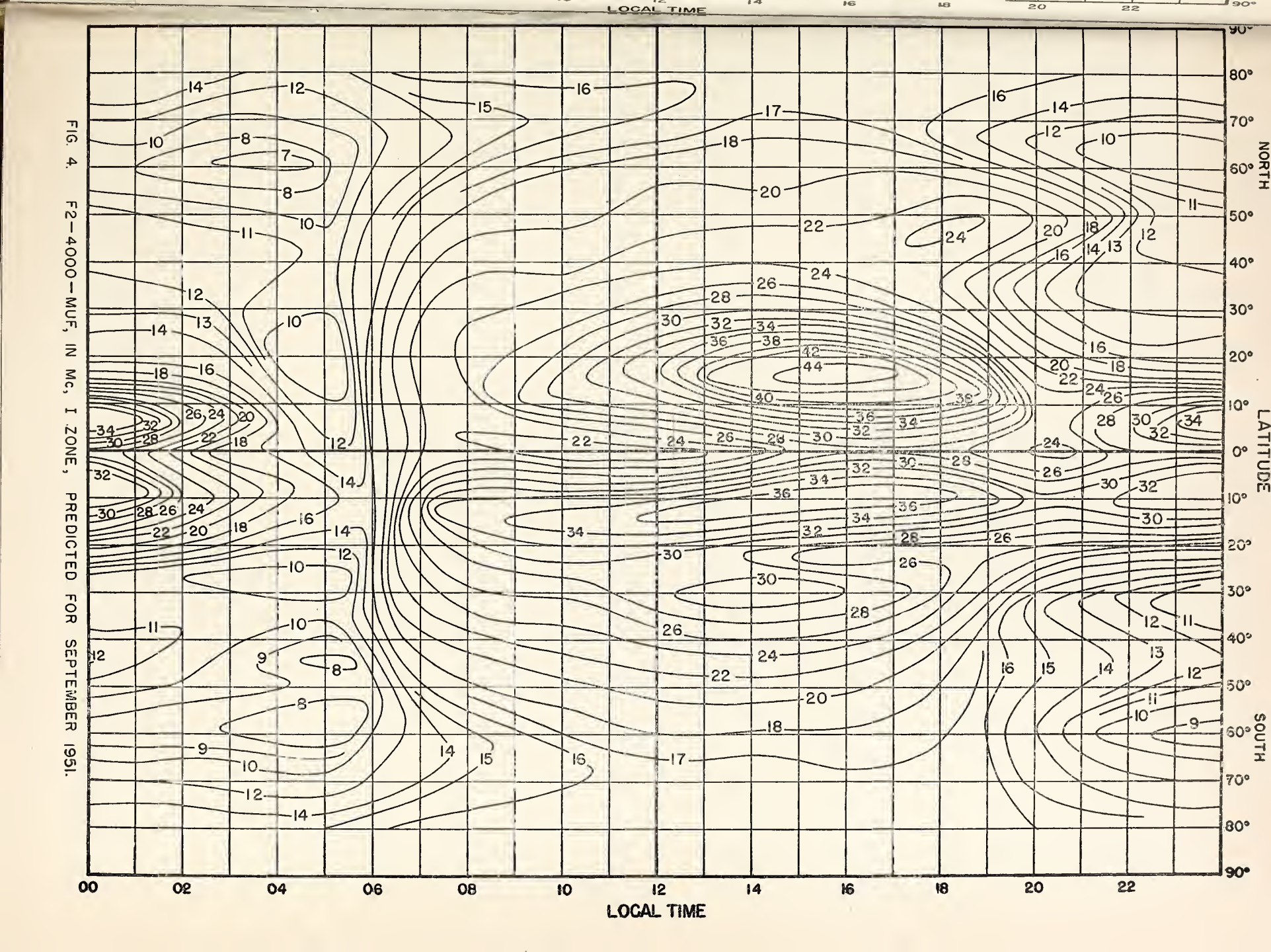


FIG. 4. F2—4000—MUF, IN Mc, I ZONE, PREDICTED FOR SEPTEMBER 1951.

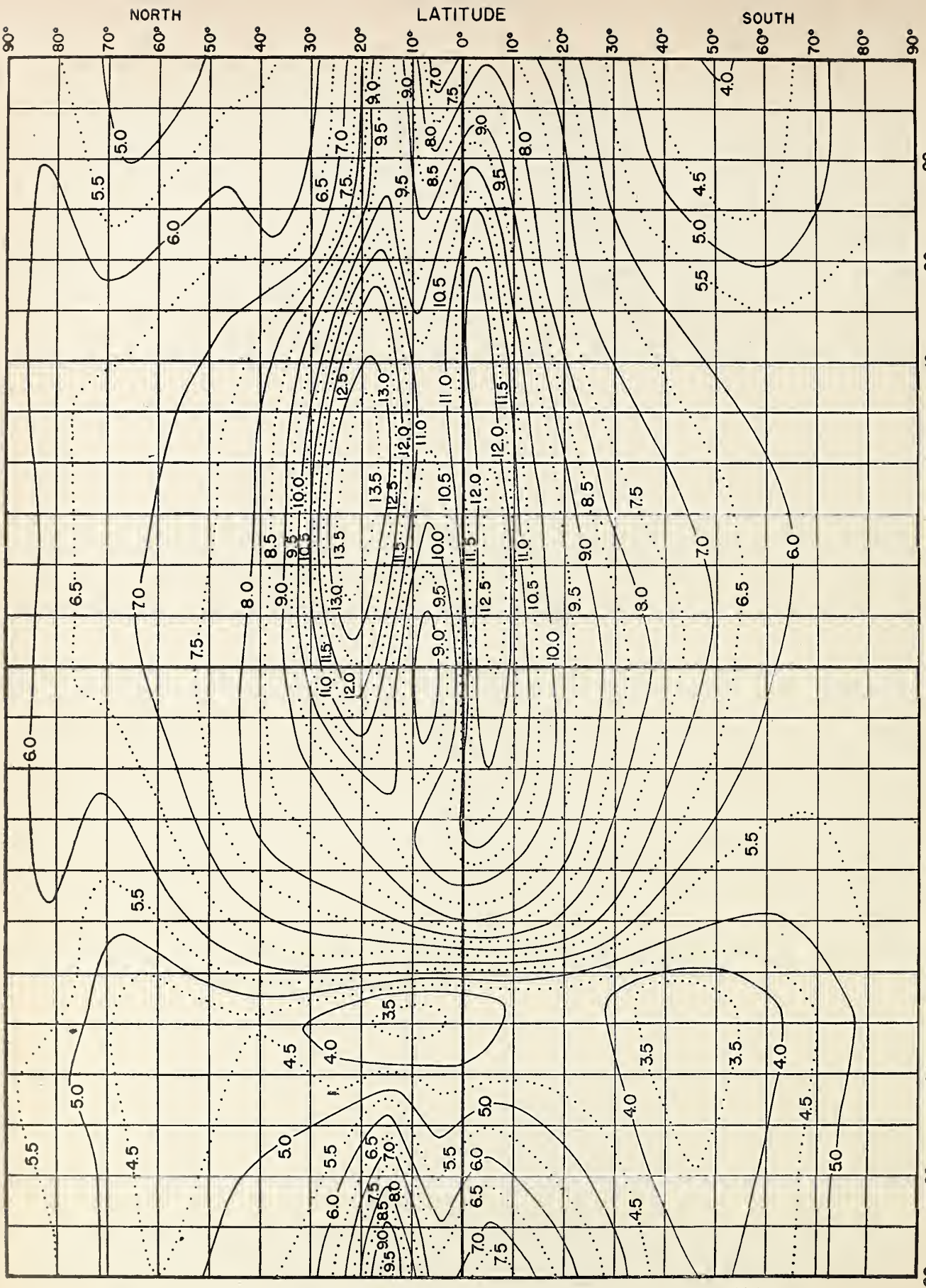


FIG. 5 F2-ZERO-MUF, IN Mc, E ZONE, PREDICTED FOR SEPTEMBER 1951.

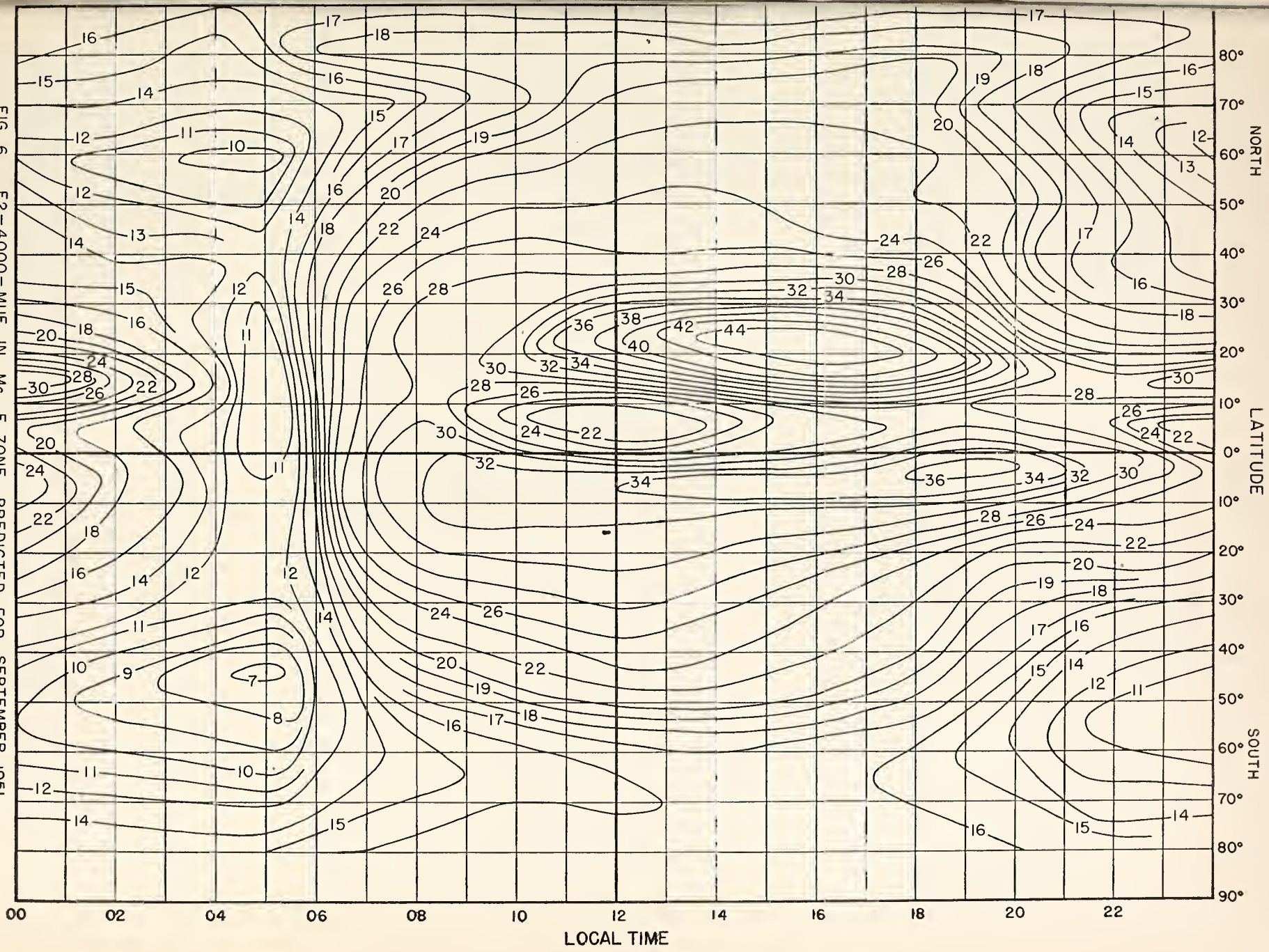


FIG. 6. F2-4000-MUF, IN Mc, E ZONE, PREDICTED FOR SEPTEMBER 1951.

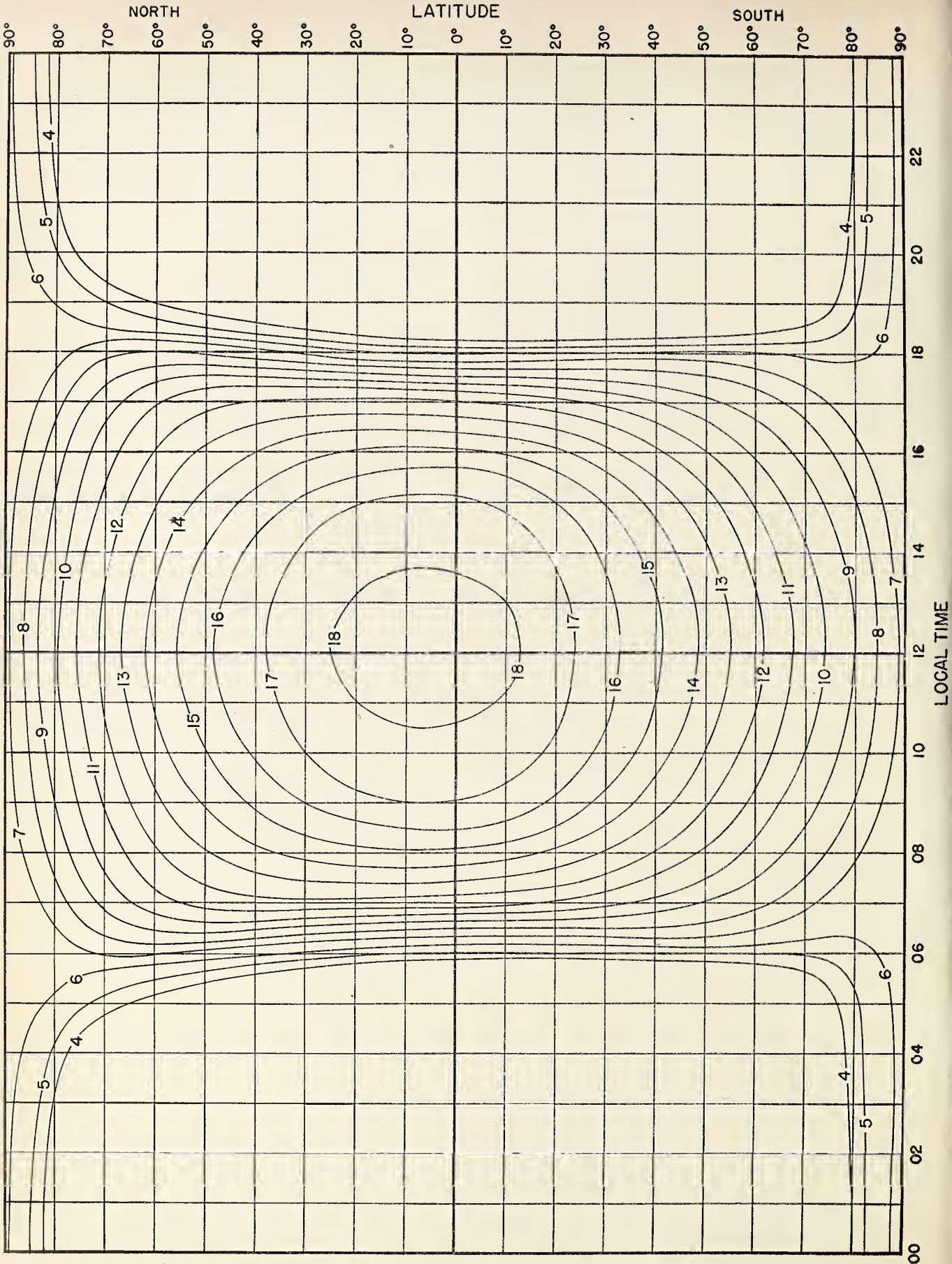


FIG. 7. E – 2000 – MUF, IN Mc, PREDICTED FOR SEPTEMBER 1951.

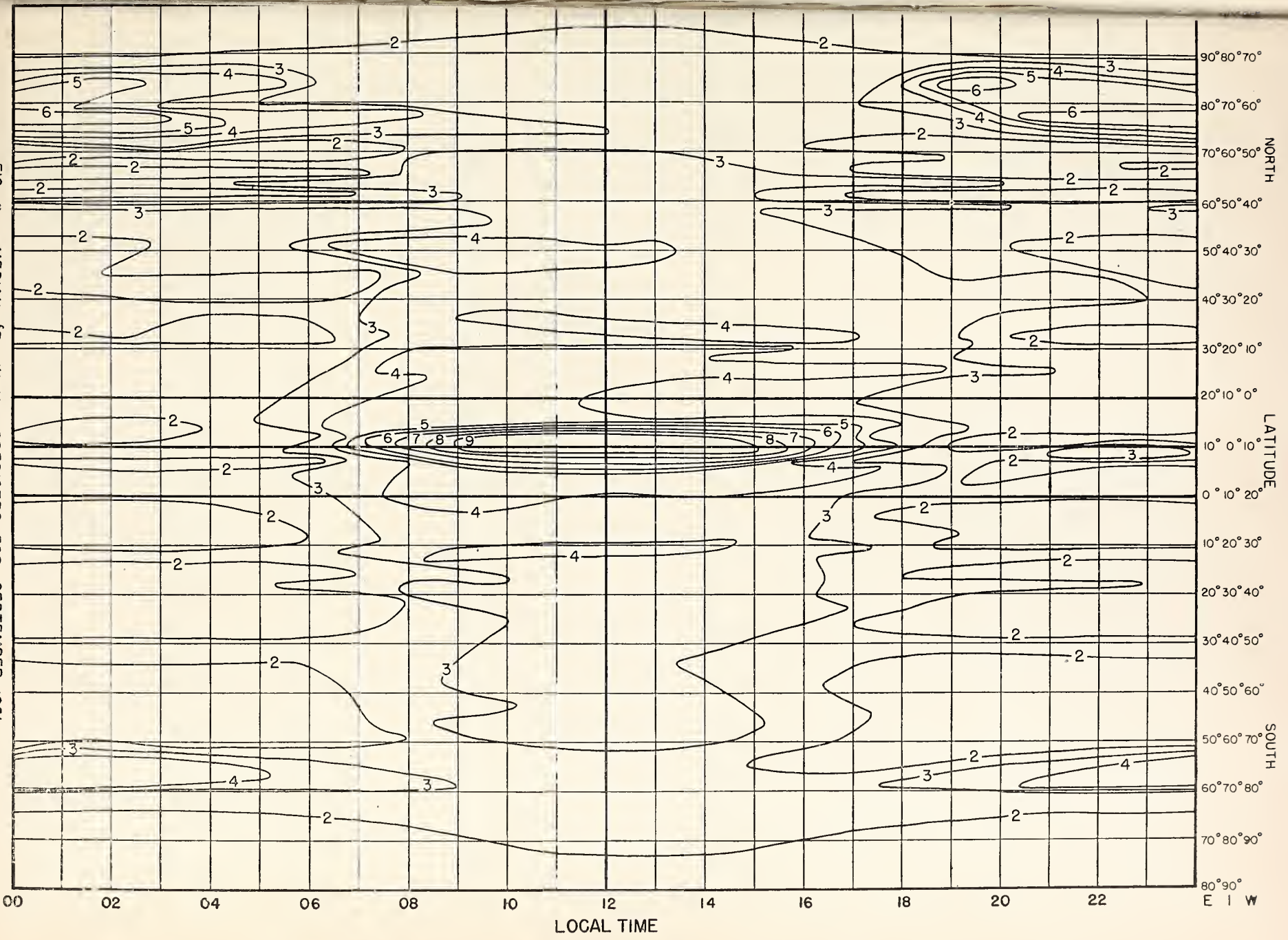


FIG. 8. MEDIAN fEs, IN Mc, PREDICTED FOR SEPTEMBER 1951.

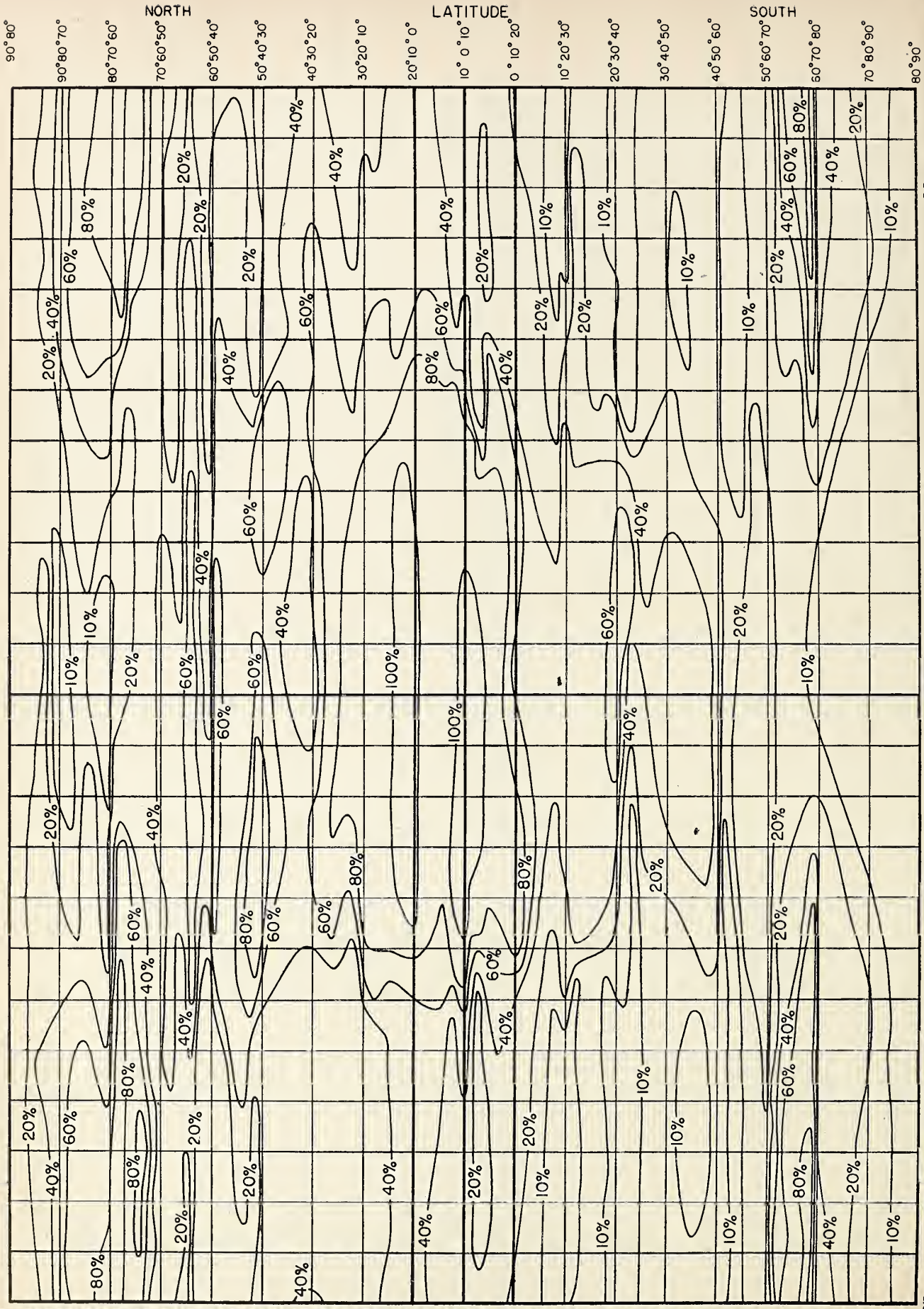


FIG 9. PERCENTAGE OF TIME OCCURRENCE FOR Es–2000–MUF IN EXCESS OF 15 Mc, PREDICTED FOR SEPTEMBER 1951.

CRPL

FORM AF

Date _____

# MUF – FOT WORK SHEET FOR PATHS 4000 KM OR LESS

From _____ To _____ Distance, _____ km Zone ____ Predicted for ____ 19__

Note: All frequencies are in megacycles.

| GCT | fEs | Es 2000-muf | E-layer 2000-muf | F2 zero-muf | F2 4000-muf | Es-muf for Path | E-F1-muf for Path | F2-muf for Path | Es 2000-fot | Es-fot for Path | E-fot for Path | F2-fot for Path | MUF for Path | FOT for Path |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | g | h | i | j | k | l | m | n |
| Procedure | Scale | 5 X a | Scale | Scale | Scale | | | | b-4.0 | | Same as g | .85 h | Highest of f, g, h | Highest of j, k, l |
| 00 | | | | | | | | | | | | | | |
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| Done by | | | | | | | | | | | | | | |
| Checked | | | | | | | | | | | | | | |

NOTE: FOT IS THE SYMBOL FOR OPTIMUM TRAFFIC FREQUENCY (FORMERLY OWF)

FORM AH

CRPL

Date _____

# MUF-FOT WORK SHEET FOR PATHS OVER 4000 KM.

From _____ To _____ Distance, _____ km Predicted for _____ 19___

Note: All frequencies are in megacycles.

| | A-end | | | | | | B-end | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pt. A in ____ Zone | | | Pt. A' in ____ Zone | | | Pt. B in ____ Zone | | | Pt. B' in ____ Zone | | | MUF | MUF | FOT | FOT | MUF for | FOT for |
| GCT | fEs | Es 2000-muf | F2 4000-muf | E-layer 2000-muf | Es 2000-fot | F2 4000-fot | fEs | Es 2000-muf | F2 4000-muf | E-layer 2000-muf | Es 2000-fot | F2 4000-fot | A-end | B-end | A-end | B-end | PATH | PATH |
| | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | p | q | r |
| Procedure | Scale pt. A' | 5 X a | Scale pt. A | Scale pt. A' | b-4.0 | .85 c | Scale pt. B' | 5 X g | Scale pt. B | Scale pt. B' | h-4.0 | .85 i | Highest of b,c,d | Highest of h,i,j | Highest of d,e,f | Highest of j,k,l | Lower of m,n | Lower of o,p |
| 00 | | | | | | | | | | | | | | | | | | |
| 01 | | | | | | | | | | | | | | | | | | |
| 02 | | | | | | | | | | | | | | | | | | |
| 03 | | | | | | | | | | | | | | | | | | |
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| Done by | | | | | | | | | | | | | | | | | | |
| Checked | | | | | | | | | | | | | | | | | | |

NOTE FOT IS THE SYMBOL FOR OPTIMUM TRAFFIC FREQUENCY (FORMERLY OWF)

(Cut along this line)

## Form for Report to CRPL on Accuracy of Predictions

**Name** _____ **Date** _____

**Address** _____ _____ _____ _____ _____ _____
No. Street City P.O. Zone State Country

**From (between)** _____ **to (and)** _____ **Date** _____

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time (specify zone) | | | | | | | | | | | | | | | | |
| Frequency Used | | | | | | | | | | | | | | | | |
| D-Series Predicted FOT (OWF) Regular Layers | | | | | | | | | | | | | | | | |
| D-Series Predicted FOT (OWF) Including Es | | | | | | | | | | | | | | | | |

Further comment (including notes on quality of communication):

# CRPL and IRPL Reports

[A list of CRPL Section Reports is available from the Central Radio Propagation Laboratory upon request]

*Daily:*

Radio disturbance warnings, every half hour from broadcast station WWV of the National Bureau of Standards. Telephoned and telegraphed reports of ionospheric, solar, geomagnetic, and radio propagation data.

*Weekly:*

CRPL–J. Radio Propagation Forecast (of days most likely to be disturbed during following month).

*Semimonthly:*

CRPL–Ja. Semimonthly Frequency Revision Factors For CRPL Basic Radio Propagation Prediction Reports.

*Monthly:*

CRPL–D. Basic Radio Propagation Predictions—Three months in advance. (Dept. of the Army, TB 11–499–, monthly supplements to TM 11–499; Dept. of the Navy, DNC 13( ) series.)
CRPL–F. Ionospheric Data.
*IRPL–A. Recommended Frequency Bands for Ships and Aircraft in the Atlantic and Pacific.
*IRPL–H. Frequency Guide for Operating Personnel.

*Circulars of the National Bureau of Standards:*

NBS Circular 462. Ionospheric Radio Propagation.
NBS Circular 465. Instructions for the Use of Basic Radio Propagation Predictions.

*Reports issued in past:*

IRPL–C61. Report of the International Radio Propagation Conference, 17 April to 5 May 1944.
IRPL–G1 through G12. Correlation of D. F. Errors With Ionospheric Conditions.
IRPL–R. Nonscheduled reports:
R4. Methods Used by IRPL for the Prediction of Ionosphere Characteristics and Maximum Usable Frequencies.
R5. Criteria for Ionospheric Storminess.
**R6. Experimental Studies of Ionospheric Propagation as Applied to the Loran System.
R7. Second Report on Experimental Studies of Ionospheric Propagation as Applied to the Loran System.
R9. An Automatic Instantaneous Indicator of Skip Distance and MUF.
R10. A Proposal for the Use of Rockets for the Study of the Ionosphere.
**R11. A Nomographic Method for both Prediction and Observation Correlation of Ionosphere Characteristics.
**R12. Short Time Variations in Ionospheric Characteristics.
R14. A Graphical Method for Calculating Ground Reflection Coefficients.
**R15. Predicted Limits for F2-Layer Radio Transmission Throughout the Solar Cycle.
**R17. Japanese Ionospheric Data—1943.
R18. Comparison of Geomagnetic Records and North Atlantic Radio Propagation Quality Figures—October 1943 Through May 1945.
**R21. Notes on the Preparation of Skip-Distance and MUF Charts for Use by Direction-Finder Stations. (For distances out to 4000 km.)
**R23. Solar-Cycle Data for Correlation with Radio Propagation Phenomena.
**R24. Relations Between Band Width, Pulse Shape and Usefulness of Pulses in the Loran System.
**R25. The Prediction of Solar Activity as a Basis for the Prediction of Radio Propagation Phenomena.
R26. The Ionosphere as a Measure of Solar Activity.
R27. Relationships Between Radio Propagation Disturbance and Central Meridian Passage of Sunspots Grouped by Distance From Center of Disc.
**R30. Disturbance Rating in Values of IRPL Quality-Figure Scale from A. T. & T. Co. Transmission Disturbance Reports to Replace T. D. Figures as Reported.
R31. North Atlantic Radio Propagation Disturbances, October 1943 Through October 1945.
**R33. Ionospheric Data on File at IRPL.
**R34. The Interpretation of Recorded Values of *fEs*.
R35. Comparison of Percentage of Total Time of Second-Multiple *Es* Reflections and That of *fEs* in Excess of 8 Mc.
IRPL–T. Reports on tropospheric propagation:
T1. Radar operation and weather. (Superseded by JANP 101.)
T2. Radar coverage and weather. (Superseded by JANP 102.)
CRPL–T3. Tropospheric Propagation and Radio-Meteorology. (Reissue of Columbia Wave Propagation Group WPG–5.)

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*Items bearing this symbol are distributed only by U. S. Navy. They are issued under one cover as the DNC 14( ) Series.
**Out of print; information concerning cost of photostat or microfilm copies is available from CRPL upon request.

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